



EX-SITU TREATMENT OF PETROLEUM SATURATED SOILS USING CHEMOX

by Glenn Nicholas Iosue, P.E.

MECX, LP

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Project Challenges

- Tight matrices, NAPL, TOC
- Site constraints & ecological considerations
- Time to remediate and cost effectiveness
- Regulatory permitting
- Total mass destruction

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Soil Remediation

- Get it done.....**Now! Cost-Effectively! Permanently!**
- Decision drivers
 - Cost: bioremediation/mass transfer technologies
 - Time: excavation & off-site disposal
 - **Optimized time and cost: excavation and ex-situ chemical oxidation (ESCO)**

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MEC^x ESCO Process

- Oxidant and Reagent Screening
- OET[©] Modeling
- Design Parameter Evaluation
- Field Application



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Chemical Oxidant Screening

Oxidant	Volts ⁽¹⁾
Hydrofluoric Acid (HF)	3.0
Hydroxyl Radical (OH•)	2.7 
Sulfate Radical (SO ₄ •)	2.6 
Ozone (O ₃)	2.4
Sulfate (S ₂ O ₈ ⁻²)	2.1
Hydrogen Peroxide (H ₂ O ₂)	1.8
Permanganate (MnO ₄ ⁻)	1.7
Chlorine (Cl ₂)	1.4

ISCO Technology	By Contaminant							Speed to Treat NAPL
	BTEX	Chlorinated ethenes	Chlorinated ethanes	Chlorinated methanes	MTBE	Hydro-carbons	1,4-Dioxane	
Klozur™ Activated Persulfate	H	H	H	H	H	H	H	H
Fenton's Chemistry	H	H	E	N	E	H	H	H
Ozone	H	H	H	E	E	H	E	E

Legend: **H – highly effective** **E – effective** **N – not effective**

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Chemical Oxidant Goals and Process Optimization

- *Goals*
 - Enhance desorbtion
 - Persistent oxidation
 - Maximize oxidant radicals
 - Total mass reduction
- *Ex-situ chemical oxidation technologies selected*
 - Sodium persulfate *activated by sodium percarbonate and iron*

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Activated Persulfate

- Persulfate activation:
 - Presence of a transition metal
 - Heat (~95°F for benzene)
 - Hydrogen peroxide
 - High pH
- When combined with iron-catalyzed hydrogen peroxide (generated from sodium percarbonate and ferrous sulfate), persulfate is activated synergistically by all of the above activation methods except UV

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Laboratory Treatability Test

- MEC^x's Oxidation Estimating Tool (OET) is predictive empirical model to estimate overall oxidant demand (OD)
- Stoichiometry is only a small fraction of the actual oxidant required for ISCO
- Treatability test is run on several formulations to develop an efficiency curve and confirm OD
- The primary purposes of the OET are:
 1. To determine the reactivity of the site media
 2. To select the optimum reagent formulation
 3. To observe adverse reactions, if any

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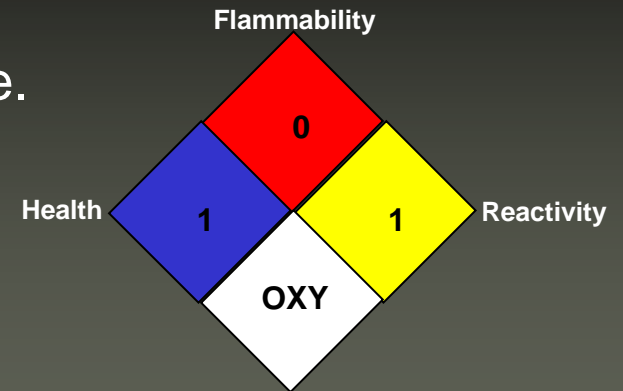
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Persulfate Safety

- All oxidizing chemicals require careful handling/use.
- Stainless steel preferred
- Other metals cause decomposition
- pH of persulfate solutions decrease over time, and may drop <2
- PPE: eyewear, gloves, chemical resistant shoes, respiratory (dust)
- Store persulfate in cool dry storage area
- Store/process persulfate solutions in vented vessels



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Site Background

- Former industrial facility
- Lithology: silty clay
- Contaminant: TPH (heating oil/diesel)
- Debris and abandoned building in soil
- Adjacent to ecologically sensitive bay

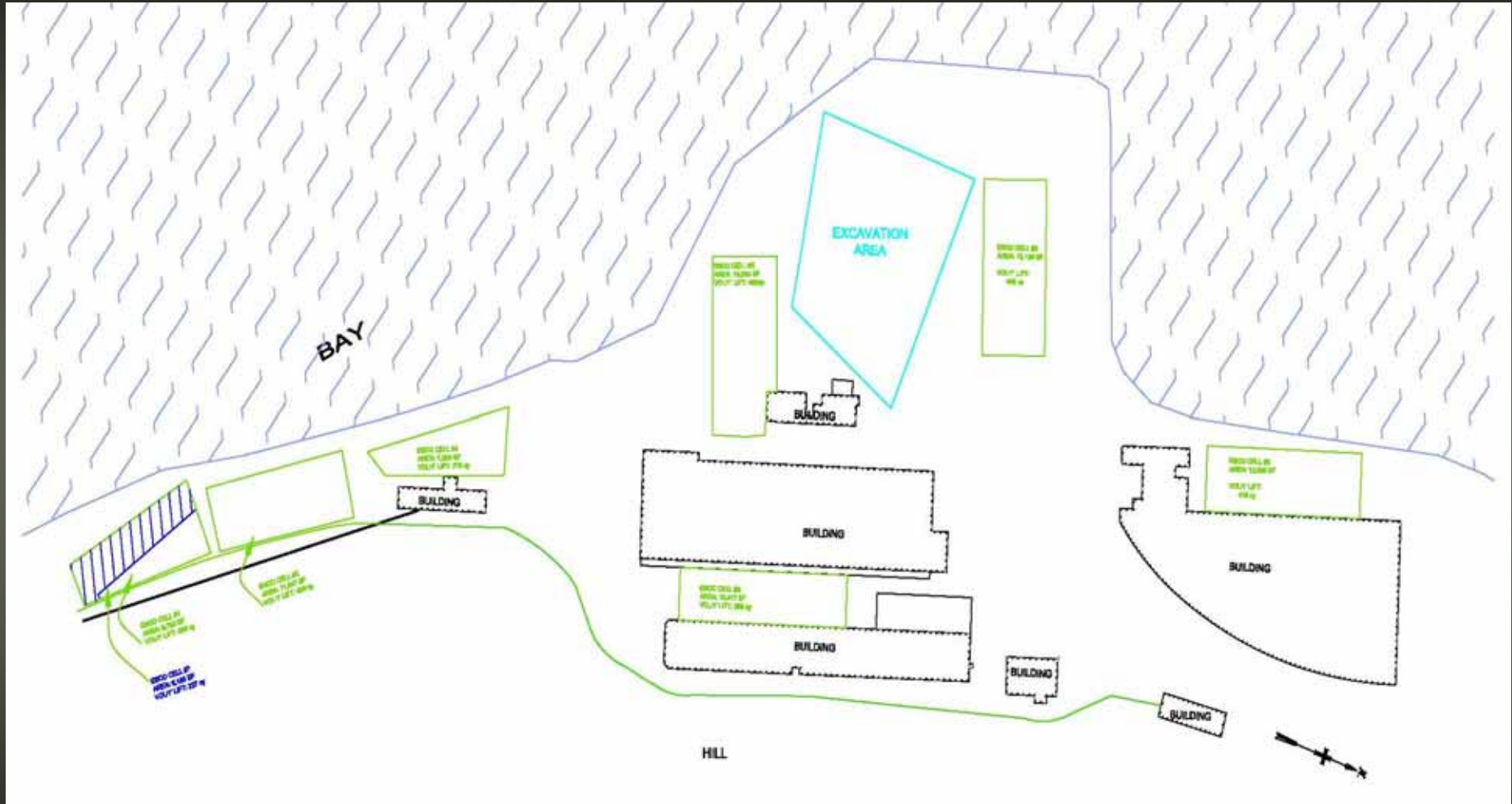
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Site Plan



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Field Application

- Treatment cells
 - 7 total
 - 200' x 75'
 - lined
- Chemical reagents
 - Application: broadcasting
 - Distribution: mixing
 - Hydration: high volume water
- Working in wet soils with yellow iron

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In-Situ vs. Ex-Situ

- Encumbrances to in-situ mixing/treatment:
 - Physical obstructions
 - Oxidant sinks



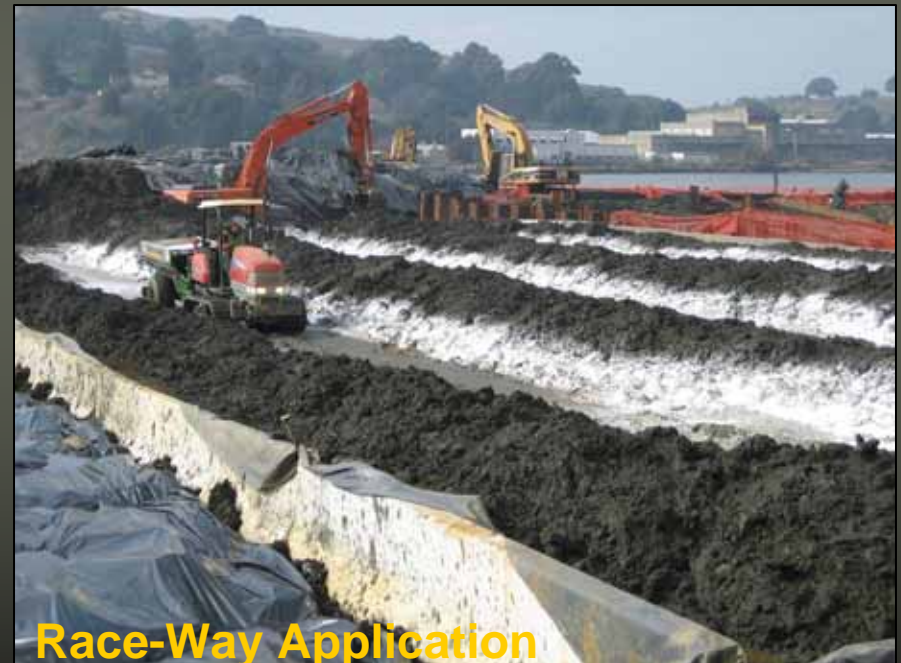
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Reagent Delivery



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Hydration



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Mixing



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Real Time Reagent Monitoring



Real-Time Persulfate Monitoring



Real-Time Iron Monitoring

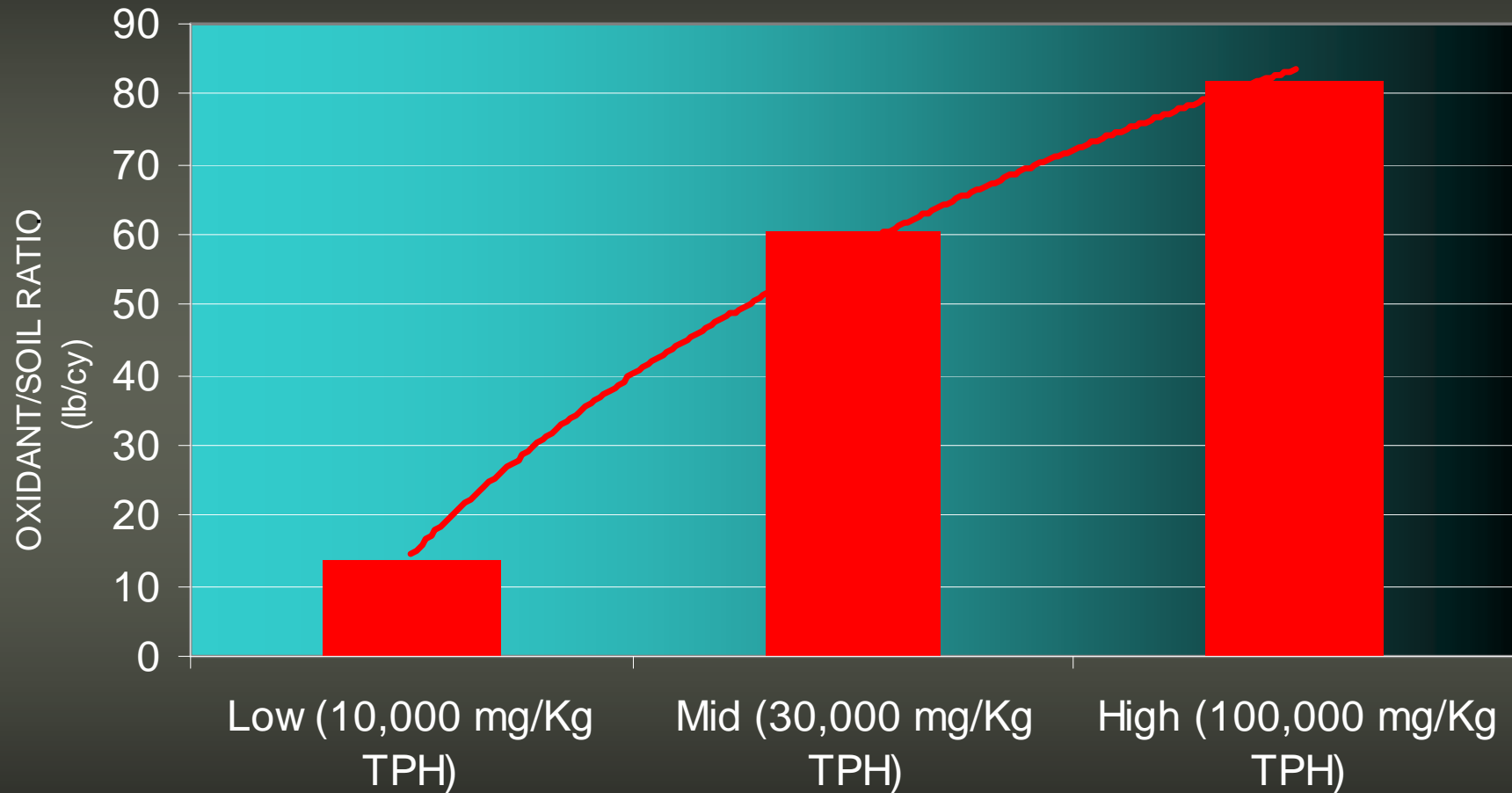
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Oxidant Efficiency



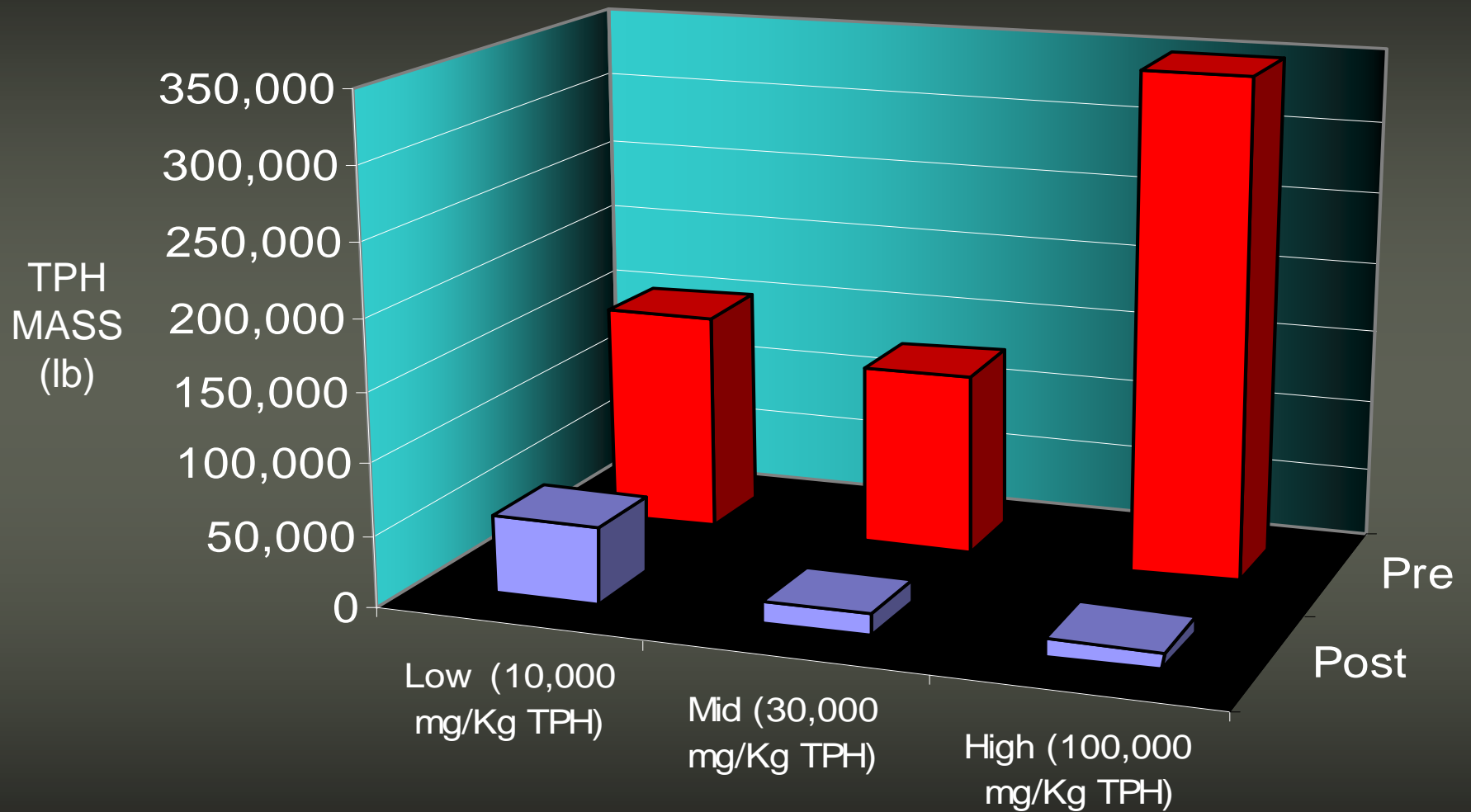
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TPH Mass Destruction



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Treatment Cost

The answer to the anticipated question.....

- Actual ESCO: \$98/cy (~\$75/ton)
- Off-site direct landfill option: \$250 - \$300/cy (not used)
- Savings to project for using ESCO: >\$1.5 million

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QUESTIONS?

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